PATENT SPECIFICATION

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(21) Application No. 2329/72 (22) Filed 18 Jan. 1972 (19)

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(54) IMPROVEMENTS RELATING TO ROTARY DRIVE CONTROLS

(71) We, MASSON SCOTT THRISSEL ENGINEERING LIMITED, a British Company, of Thrissell Works, Easton Road, Bristol, do hereby declare the invention, for which

tion of the other. Various mechanisms exist to produce this speed variation and one example is shown in diagrammatic perspective in Figure 1 of the accompanying

ERRATA

SPECIFICATION NO 1385053

Page 4, line 55, *after* means *insert* responsive to said signalling means

Page 4, line 87, *for* or *read* for

Page 4, line 89, *for* variably *read* variable

Page 4, line 101, *for* or *read* for

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13 October 1976

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length will be produced (equal to the effective knife circumference). If shorter lengths are desired from the same apparatus with the same web speed then the knife has to move faster in order to cut with greater frequency. If its speed were increased uniformly then the knife edge would be travelling faster at the instant of cutting than the web. The solution is therefore to increase the knife speed over a large part of each revolution and to slow it down for the cutting period. Likewise, if longer sheet lengths are to be produced the knife may be slowed down over the greater part of its rotation and speeded up at the cutting period. The web speed, too, may be variable to adjust the sheet length, in which case the knife speed must be altered correspondingly for the cutting period.

Although there are two variables (knife speed and draw roll speed) it is convenient to have a single linked control so that variation of one produces a corresponding varia-

[*Price 33p*]

knife 23 *via* gears 24.

It will be seen that with a constant rotational speed of the shafts 4 and 7 and for a given position of the pivot block 18 offset from a position coaxial with the shaft 12, the knives 22 and 23 will be driven at a speed that varies during each revolution. The amount of this cycle variation depends on the position of the pivot block 18, which can be adjusted to alter the axis of rotation of the crank 16, the effect of the link 15 on that crank and thus the effect of the link 17 on the crank 21.

The lower end of the belt 25 of the Reeves gear is trained around a roller 26 whose effective diameter is adjustable by means of a screw 27, which is the member that effectively determines the sheet length. This screw 27 is linked through a shaft 28, a worm 29, a quadrant 30 and a shaft 31, to a sheet length indicator 32. It is also linked by bevel gears 33 and a shaft 34 to a gear

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(54) IMPROVEMENTS RELATING TO ROTARY DRIVE CONTROLS

(71) We, MASSON SCOTT THRISSEL ENGINEERING LIMITED, a British Company, of Thrissell Works, Easton Road, Bristol, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to rotary drive controls. It is particularly concerned with the drive that is imparted to a rotary knife when cutting a continuous web, of paper for example, into lengths.

A common arrangement is to have a continuous web of paper fed by draw rollers rotating at a uniform speed into the nip between a single rotary knife and a fixed knife or between two co-operating rotary knives. It is desirable to have the knife edge moving at the same speed, or at a fixed overspeed (typically 5%—10%), as the paper at the instant of cutting. However, for a given effective knife diameter and a constant corrsponding web and knife speed this means that only sheets of a certain length will be produced (equal to the effective knife circumference). If shorter lengths are desired from the same apparatus with the same web speed then the knife has to move faster in order to cut with greater frequency. If its speed were increased uniformly then the knife edge would be travelling faster at the instant of cutting than the web. The solution is therefore to increase the knife speed over a large part of each revolution and to slow it down for the cutting period. Likewise, if longer sheet lengths are to be produced the knife may be slowed down over the greater part of its rotation and speeded up at the cutting period. The web speed, too, may be variable to adjust the sheet length, in which case the knife speed must be altered correspondingly for the cutting period.

Although there are two variables (knife speed and draw roll speed) it is convenient to have a single linked control so that variation of one produces a corresponding variation of the other. Various mechanisms exist to produce this speed variation and one example is shown in diagrammatic perspective in Figure 1 of the accompanying drawings.

In Figure 1 a motor 1 drives a flywheel 2 by a belt 3 at a constant speed. The flywheel is mounted on a shaft 4 carrying part of a Reeves gear 5 and transmitting drive via bevel gears 6 to a knife drive shaft 7 carrying a flywheel 8 and a gear 9.

The gear 9 is part of a train 10 by which drive is transmitted to a gear 11 coaxially, and freely, mounted on one of the rotary knife shafts 12. A crank 13 is carried by the gear 11 and a stub shaft 14 at its free end is connected by a link 15 to one end of a substantially centrally pivoted arm 16 whose other end also has a connecting link 17. The arm 16 also serves as a crank and is freely pivoted to a block 18 whose position can be adjusted by a screw 19 in a manner to be described later. The other end of the link 17 is connected to a crank 21 on the shaft 12 to drive the upper rotary knife 23 *via* gears 24.

It will be seen that with a constant rotational speed of the shafts 4 and 7 and for a given position of the pivot block 18 offset from a position coaxial with the shaft 12, the knives 22 and 23 will be driven at a speed that varies during each revolution. The amount of this cycle variation depends on the position of the pivot block 18, which can be adjusted to alter the axis of rotation of the crank 16, the effect of the link 15 on that crank and thus the effect of the link 17 on the crank 21.

The lower end of the belt 25 of the Reeves gear is trained around a roller 26 whose effective diameter is adjustable by means of a screw 27, which is the member that effectively determines the sheet length. This screw 27 is linked through a shaft 28, a worm 29, a quadrant 30 and a shaft 31, to a sheet length indicator 32. It is also linked by bevel gears 33 and a shaft 34 to a gear

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SEE ERRATA SLIP ATTACHED

box 35 at the output of a sheet length adjusting motor 36. This motor 36 is governed by a sheet length pre-selector 37 and its other output shaft 38 rotates, by bevel gears 39, the screws 19 on which the pivot block 18 is mounted.

The roller 26 also drives through bevel gears 40 and a shaft 41 the draw rolls (not shown) by which the paper web is fed through the knives.

An adjustment of the speed of the draw rolls by rotation of the screw 27 will increase or decrease the sheet length, for the speed of the shafts 4 and 7 remains unaffected and the cyclic period of the knives is constant for a given speed of the motor 1. However, the shaft 38, which is rotated with the screws 27, alters the position of the pivot block 18 by means of the screw 19 and thereby automatically changes the knife speeds during each cycle. With suitable gearing the knife speed at the cutting instant can be made substantially equal to the web speed over a given range of web speeds. The shafts 28 and 31 also rotate with the screw 27 to indicate what length is being cut at the new speed.

This sheet length alteration may be carried out by the pre-selector 37 which, when moved to a new position causes the motor 36 to rotate the shaft 34 and thus the screw 27 to change the web speed and also to rotate the shaft 38 and hence alter the position of the pivot block 18.

This mechanical coupling of the drives by shaft 34 is not entirely satisfactory, however, as it does not always give an accurate synchronisation of the knife speed and the paper web speed at the instant of cutting at all paper speeds and for all sheet lengths within the range of the machine.

There are other means for producing the varying knife speeds including four-bar linkages, elliptical gears and sophisticated yokes with sliding elements. There may also be separate motors driving knives and draw rolls.

It is an object of this invention to improve the synchronisation of knife speed and web speed at the instant of cutting in any of the known arrangements described.

According to the present invention to improve the synchronisation of knife speed and web speed at the instant of cutting in any of the known arrangements described.

According to the present invention there is provided apparatus for controlling the rotation of a first member that rotates at cylindrically non-uniform speed per revolution in a desired relationship to the rotation of a second member so that circumferential speeds of said members have a predetermined relationship over part of a revolution of said first member, comprising a cyclically variable transmission in the drive to the first member, said transmission including means to create said cyclically non-uniform speed per revolution of said first member, signal producing means associated with each member for giving an output representative of the associated speed over a period corresponding to said part revolution, means or signalling the commencement of said part revolution comparator means responsive to said signalling means and to said outputs to give a signal indicating relative speeds over said part revoluton, and control means for the variable transmission governed by the relative signal to adjust said transmission to maintain the rotation of said first member during said part revolution in said predetermined relation with said second member.

In the example described above where a continuous web of paper is cut into lengths, the part revolution corresponds to cutting period.

Referring back to Figure 1, with the control system of the invention ,instead of the mechanical link provided by the shaft 34, there need be no direct mechanical connection between the adjusting screw 27 and the shaft 38. Instead, the shaft 12 can be provided with signal producing means, various kinds of which are referred to below, as would shaft 41, and each of these would have associataed sensing means which produce an output corresponding to the speeds of rotation of those shafts. A comparison is made of these outputs over the cutting period and a control signal is fed to the sheet length adjusting motor 36 to rotate the shaft 38 ,and thus the screw 19, to position the block 18 so that the output from the sensor associated with the shaft 12 over the cutting period corresponds to the web speed indicated by the output from the sensor associated with the shaft 41. The sheet length is changed by direct manual rotation of the screw 27 and not by a motor following a pre-selector.

For a better understanding of the invention some constructional forms thereof will now be described, by way of example, with reference to the remaining figures of the accompanying drawings, in which:

Figure 2 is a circuit diagram of a control apparatus according to the invention,

Figure 3 is a circuit diagram of an alternative control apparatus, and

Figure 4 is a schematic diagram of a further control apparatus.

In Figure 2, the shaft 41 has a coaxial disc 42 fixed thereto with a radial grating 43. The passage of the radial lines past a fixed transducer 44 as the shaft 41 rotates results in pulses being fed to a counter 45 via a gate 46. The shaft 12 also has a coaxial disc 47 fixed thereto with a radial grating 48. A part-annular array of lines is all that is

really necessary on shaft 12 but discs with a full grating are more readily available and so are preferred. A transducer 49 co-operates with these lines and produces pulses that are fed to a counter 50 via gate 51. Also fixed to the shaft 12 is a trip 52 which co-operates with a switch 53 so disposed that it is actuated shortly before the knives cut. The trip and switch may be mechanical but are preferably electronic or magnetic. When actuated the switch opens the gates 46 and 51 so that the pulses from the transducers 44 and 49 are counted by the resective counters 45 an 50. The gates 46 and 51 are held open for at least the cutting period, and when completed this is compared in a circuit 54 with the pulse count over the same period from the counter 45.

Assuming the effective diameter of the knives to be the same as the diameter of the draw rolls, and the two radial gratings to be the same, then over the cutting period the knife requires to travel at the same speed as the draw rolls and the two radial gratings to be the same, then over the cutting period the knife requires to travel at the same speed as the draw rolls and the same number of pulses should be produced from each transducer. Any difference in the count results in an output from the comparator 54 which is fed to a motor control circuit 55 that governs in the example of Figure 1, the motor 36. This is operated to alter the position of the block 18 and thus the speed of the knife over the cutting period, the alteration being such that the difference in the pulse counts over the cutting period is reduced to zero.

It will be understood that the comparative signal may be used to control any knife and/or draw roll drive system.

Of course the diameter of the draw rolls will not necessarily be the same as the effective diameter of the knives, in which case if similar radial gratings are used a different number of pulses will be produced during the cutting period when the knife is moving at the correct synchronised speed. In this case the comparator 54 must be adapted to compare these different numbers and only produce a corrective output when the difference departs from the one to which the comparator is set. Alternatively, the radial gratings may be individually adapted to their respective shafts so that despite different diameters, there will be the same pulse count from each over the cutting period. However, this is not preferred as radial gratings are expensive and it is simpler to provide standard gratings and design the electronic circuitry to cope with them.

It will be understood that the lines of the radial grating 43 must extend over a complete annulus whereas the grating 48 need only be part annular over a sector corresponding to the cutting period. In this case the initial pulse can be used as the trigger to commence the respecitve counts. Where the grating 48 is completely annular, the switch 53 and the trip 52 may be such that they maintai nthe gates 46 and 51 open only for the cutting period, in which case the counter 50 does not have to be adapted to count to a specific member but only to count during a certain period. This may result in a not exactly uniform number of pulses being counted from the grating 48 every revolution, but the difference from cycle to cycle will be so slight as not to make any practical difference. In any of the above examples the pulse counts may be averaged over a number of revolutions in order to minimise the effect of slight miscounts.

There are other forms of signal producing and sensing means that can give an indication of shaft speeds. For example precision tachometers are known which will produce a voltage directly proportionally to speed. A simplified circuit diagram of a system using tachometers is shown in Figure 3. A gate system as in Figure 2 is used, and referenced similarly, and the outputs of the tachometers 56 and 57 are fed through those gates during the cutting period to a voltage comparator 58. The output of this governs a motor control circuit in the manner described above.

Instead of having the drive to the draw rolls and the rotary knives mechanically linked they may each be driven by separate motors which of course will have to be synchronised according to the desired sheet length. It is convenient to use for this purpose the means which detect the synchronism of the speed of the knives during the cutting period with the draw roll speed.

The two independent drives are indicated by electric motors 60 and 61 in Figure 4. A tachometer 62, for example, gives a voltage that corresponds to the speed of the draw rolls and the tachometer 63 gives a fluctuating voltage corresponding to the varying rotational speeds of the rotary knives. Over the cutting periods these can be gated, as in Figure 3, and compared in circuit 64 to give an output that can synchronise the motors or the instant of cut by altering the variable transmission 65, exemplified in Figure 1 by the motor 36 and elements 13 to 19.

The tachometer readings can also be used to govern the relative motor speeds. The fluctuating voltage from tachometer 63 is averaged in circuit 66 and the mean angular velocity of the knives is derived. The ratio of this to the angular velocity of the draw rolls derived from tachometer 62 is compared in circuit 67 with an input from a sheet length control circuit 68. This input, a voltage for example, represents a desired sheet length, and sheet length depends on

the comparative speeds of the motors 60 and 611. Any departure of actual sheet length from the desired one results in an output that is fed back to motor 60 to adjust the speed thereof.

It will be seen that the ratio determining and comparator circuit 67 replaces the positive infinitely variable gear box exemplified by the Reeves drive of Figure 1.

It will also be understood that instead of an analogue method using tachometers there could be substituted a digital method, for example using the radial gratings of Figure 2.

The constant speed of the motor 61 could also be directly obtained, as by a further tachometer or another radial grating, and fed to the circuit 67, so eliminating circuit 66. However that is probably the more expensive solution.

It has been assumed in the above that the drive to the draw rolls is variable while that of the shaft 7 or motor 61 is constant. It will be appreciated that the opposite arrangement might be adopted.

It will also be understood that the speeds need not be the same at the cutting instant and that a slight overspeed of the knives, as referred to initially, may be provided for.

It will be understood that the invention can be applied to operations other than cutting, for example creasing, embossing stamping and repetitive rotary welding of plastics bags or sachets.

WHAT WE CLAIM IS:—

1. Apparatus for controlling the rotation of a first member that rotates at cyclically non-uniform speed per revolution in a desired relationship to the rotation of a second member so that circumferential speeds of said members have a predetermined relationship over part of a revolution of said first member, comprising a cyclically variable transmission in the drive to the first member, said transmission including means to create said cyclically non-uniform speed per revolution of said first member, signal producing means associated with each member for giving an output representative of the associated speed over a period corresponding to said part revolution, means for signalling the commencement of said part revolution, comparator means and to said outputs to give a signal indicating relative speeds over said part revolution, and control means for the variable transmission governed by the relative signal to adjust said transmission to maintain the rotation of said first member during said part revolution in said predetermined relationship with said second member.

2. Apparatus as claimed in claim 1, wherein the signal producing means are digital and pulses are counted to indicate the rotational speeds.

3. Apparatus as claimed in claim 2, wherein radial gratings rotate with said first and second members and sensing means are associated with each grating.

4. Apparatus as claimed in claim 1, wherein said signal producing means are analogue and produce continuous signals indicative of rotational speeds.

5. Apparatus as claimed in claim 4, wherein the analogue signal producing means include tachometers.

6. Apparatus as claimed in any preceding claim wherein the means for signalling the commencement of said part revolution includes a trip rotating with said first member.

7. Apparatus as claimed in any preceding claim, wherein there is a single prime mover or both members, the drive to said second member being through infinitely variably transmission means.

8. Apparatus as claimed in any one of claims 1 to 6, wherein said members have separate prime movers, the relative speeds of which are monitored and applied to control said second member to maintain a desired relationship between the mean speed of rotation of said first member and the speed of rotation of said second member.

9. Apparatus as claimed in claim 8, wherein said moitoring is provided by said signal producing means, the signal producing means or the first member being arranged to give an output throughout a revolution which is averaged to indicate the mean cyclic speed.

10. Apparatus for controlling rotary drives substantially as herein before described with reference to Figure 2, 3 or 4 of accompanying drawings.

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1385053 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

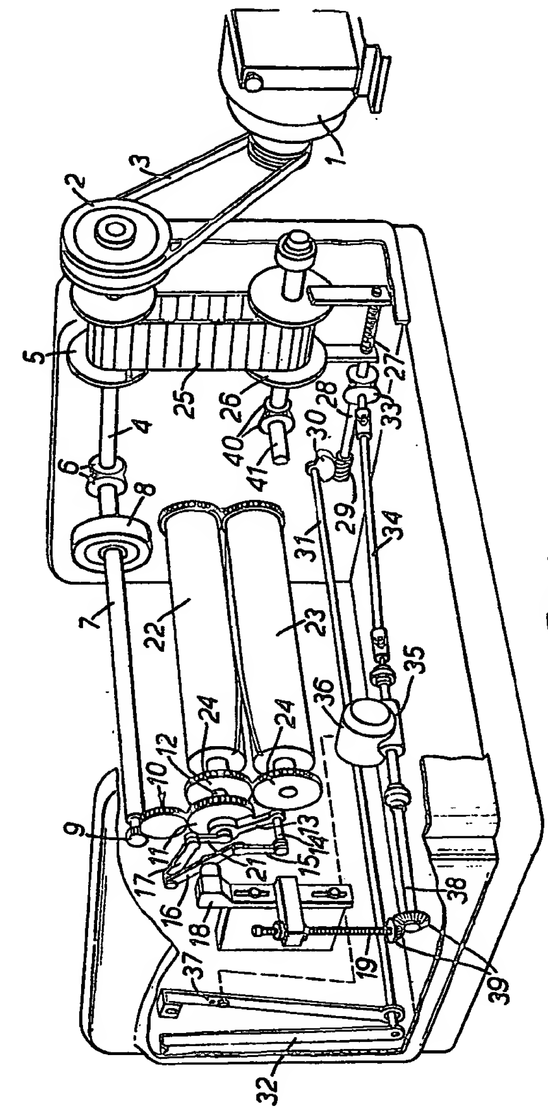

FIG. 1.

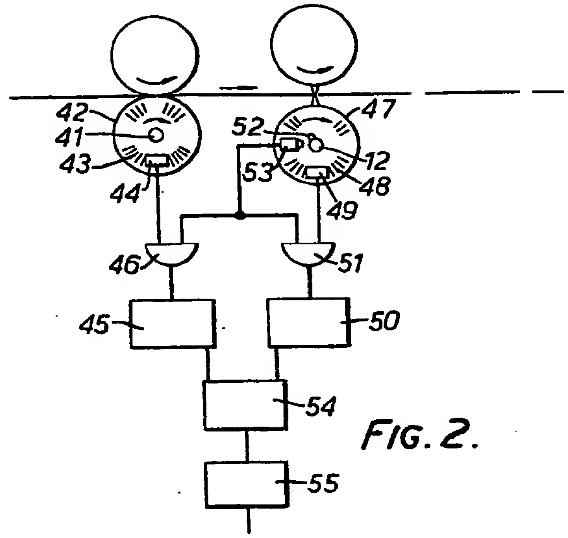

FIG. 2.

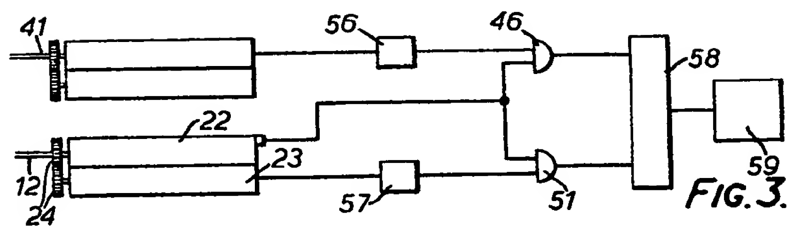

FIG. 3.

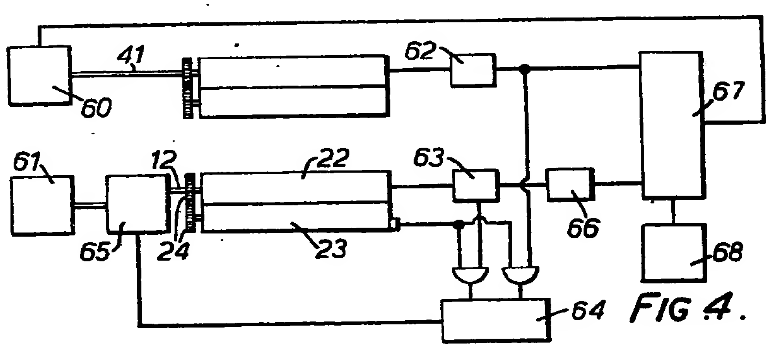

FIG 4.